DSN Telemetry System Mark III-77

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This article provides a description of the DSN Telemetry System, Mark III-77, and the recent improvements. Telemetry functions and performance are identified.

I. Introduction

The Deep Space Network Telemetry System has been described in Ref. 1. The current system configuration described below has been implemented by incremental changes and upgrades to existing equipment configurations. The system is now configured to provide support for the following missions:

(1) Voyager.

(2) Pioneers 6 through 11.

(3) Pioneer Venus 78 Orbiter and Multiprobe.

(4) Helios.

(5) Viking.

(6) Galileo.

II. System Definition

The DSN Telemetry System provides the capability to acquire, process, decode, and distribute deep space probe telemetry data. Telemetry data are defined as consisting of science and engineering information modulated on radio signals transmitted from the spacecraft.

The DSN Telemetry System, Mark III-77, performs three main functions:

(1) Telemetry data acquisition.

(2) Telemetry data conditioning and transmission.

(3) Telemetry system validation.

Telemetry data acquisition consists of those functions necessary to extract the telemetry information modulated on the downlink carrier(s) of the spacecraft. Telemetry data conditioning and transmission consist of those functions necessary to decode, format, record, and transmit the data to users. Telemetry System validation consists of those functions necessary to validate the performance of the Network in the acquisition, conditioning, and transmission of telemetry data. Verification of correct system performance is made and corrective action is taken when such performance does not meet specifications.

III. Key Characteristics

The key characteristics of the DSN Telemetry System, Mark III-77, consist of:

(1) High-rate (up to 250 ksps) X-band telemetry capability at both a 34- and a 64-meter subnet, in addition to S-band telemetry at all subnets.

(2) Maximum likelihood decoding of short constraint length convolutional codes at all Deep Space Stations (DSS). Deletion of block decoding after completion of Viking Mission.

(3) Replacement of the Telemetry and Command Processor with a dedicated processor for telemetry, the Telemetry Processor Assembly (TPA).

(4) Centralized monitoring and control of the DSN Telemetry System by the Network Operations Control Center (NOCC).

(5) Precise measurement of received signal level and system noise temperature.

(6) Real-time reporting of DSN Telemetry System status through the DSN Monitor and Control System.

(7) Low-loss onsite recording of predetection analog/digital records with non-real-time playback.

(8) Production of a digital Telemetry Original Data Record (ODR) at each DSS with playback via local manual control or in automatic response to GCF inputs.

(9) Simultaneous reception of five carriers at selected DSS for Pioneer Venus (to be deleted after the mission).

(10) Replacement of the Data Decoder Assembly (DDA) and incorporation of its functions into the TPA.

(11) Increased high-speed data (HSD) line rate to 7200 b/s, and wideband capability standard of 56 kb/s, up to 230 kb/s at selected DSS.

(12) Generation of a Telemetry Intermediate Data Record (IDR), a time-merged record of all received telemetry data.

(13) Real-time arraying of signals received from two DSSs at the same longitude.

IV. Functional Description

A simplified block diagram of the system is shown in Fig. 1. Predicts messages are initially generated at the NOCC for high-speed data line (HSDL) transmission to the DSS for the purpose of selecting the proper data modes and configurations. Such messages consist of predicted signal levels and tolerances.

At the Deep Space Station, the received spacecraft signal is amplified by the Antenna Microwave Subsystem (UWV). The RF carrier is tracked by the Receiver-Exciter Subsystem (RCV), and the telemetry spectrum is routed to the Subcarrier Demodulator Assembly (SDA). The subcarrier is regenerated by the SDA and the symbol stream is demodulated. The resulting demodulated symbol stream is passed to the Symbol Synchronizer Assembly (SSA), where it is digitized. The digitized stream for convolutional encoded data is then routed to (1) the Maximum Likelihood Convolutional Decoder (MCD) for decoding of short-constraint-length convolutional codes, or (2) the TPA for decoding of long-constraint-length convolutional codes or uncoded data. The digitized symbol stream for block encoded data is sent to either the TPA or the Block Decoder Assembly (BDA), depending on the rate. All data are formatted for high-speed or wideband data line transmission by the TPA.

A special configuration at DSS 14 and DSS 43 for the Pioneer Venus 78 entry mission allows simultaneous reception of five carriers and for the processing of four carriers in real-time. For backup purposes, four open-loop receivers are used with bandpass filters and an analog recorder. This combination allows for recording a wideband spectrum around the anticipated carrier frequencies of the four atmospheric probes. In non-real-time, at CTA-21, these data can be played back and converted up to S-band for reception and processing by conventional receiver/SDA/SSA/TPA telemetry equipment.

At each DSS, an ODR of the decoded data is written in GCF blocks by either the TPA for high-rate data or the Communications Monitor and Formatter Assembly (CMF) for low-rate data. The data are passed to the high-speed or wideband buffer, depending upon the data rate. All data are formatted by the TPA for high-speed or wideband data line transmission.

The data are then transmitted to the Mission Control and Computing Center (MCCC) or Remote Mission Operations Centers (RMOC) and, in parallel, to the NOCC. At the NOCC, a limited amount of decommutation of engineering telemetry data is performed to analyze system performance and to obtain certain spacecraft parameters useful in controlling the Network. The NOCC also receives and displays DSN Telemetry System parameters.

A log tape containing all data received at the NOCC, either in real-time or by recall, is generated by the Network Log Processor (NLP). This log is the Network Data Log (NDL). The Data Records Assembly provides for the recall of data from the station ODRs, and for merging the recalled data with data on the NDL. It also provides for the generation of the IDR.

DSN Telemetry System performance is validated by the NOCC Telemetry Subsystem Real-Time Monitor (RTM) Processor in response to the controls and standards and limits applied from DSN Operations personnel in the Network

Operations Control Area (NOCA). Telemetry System alarms, status, and data are transmitted from the NOCC Telemetry RTM to the NOCC Display Subsystem. DSN Telemetry System alarms and status are also transmitted to the DSN Monitor and Control System and are included in the Network Performance Record (NPR). A DSN Telemetry System Performance Record (SPR), containing status and alarms, is maintained for non-real-time analysis. The SPR also contains a list of all telemetry data gaps. This list is used by the Data Records Assembly to compose recall requests from the station ODRs.

The DSN Test and Training System is used to provide simulated DSN Telemetry System data and test signals for the checkout of the system and for the training of DSN personnel.

V. System Configuration

The current configuration of equipment comprising the DSN Telemetry System is shown in Fig. 2. One 26-meter subnet–DSS 12, 42, and 61–is being upgraded to 34-meter diameter and converted to X-band Operation. DSS 12 conversion has been completed; the conversions of DSS 42 and 61 are now being implemented and will be complete by April 1980.

A. System Performance

1. **Output delay.** All spacecraft telemetry data received at the DSS are delivered in real-time to the flight project interface. The data are delayed only for (1) the time to fill on GCF data block, and (2) the ground communications transmission time.

2. **Reliability.** The DSN Telemetry System is designed to perform continuously with outages for a given telemetry stream not to exceed the following counts:

(1) Not more than one outage exceeding 15 minutes in 12 hours.

(2) Not more than 10 outages exceeding 1 minute in 24 hours.

(3) Not more than 2% total outage time in one year of scheduled operation.

Outages are defined as failures resulting in total loss of signal and requiring reconfiguration, reinitialization, or replacement of an element in the system, not the introduction of a random bit error or burst of errors.

3. **Restoration of service.** The DSN Telemetry System is capable of physical repair or replacement of failed elements within 15 minutes of the detection of a failure (provided redundant elements are available). When redundant elements are energized, configured and initialized, switching from failed elements to backup elements can be accomplished in 6 minutes.

4. **Initiation time.** After configuration of the DSN Telemetry System (connection, application of power, programs loaded on all online assemblies) for a particular operation, the System is capable of initialization within 10 minutes. Within a facility, this initialization is possible by a single operator for the facility.

5. **Reconfiguration time.** Scheduled reconfiguration of the DSN Telemetry System from support of one flight project to another can be performed within 15 minutes without prepass or postpass calibration. The capability exists for a single operator to accomplish this reconfiguration at each facility. Scheduled changes in operating mode (data rate, format, etc.) for one flight project are accomplished in 5 minutes; these changes are capable of being accomplished by a single operator for the facility.

B. DSS Modification

The following telemetry system modifications are being installed in addition to the capability defined in Ref. 1.

1. **Telemetry arraying.** At each complex (i.e. Goldstone, Spain, and Australia), capability is being provided for combining subcarrier spectrum outputs from 64- and 34-meter DSS to provide a single enhanced stream. This arraying includes automatic acquisition and synchronization not to exceed 5 minutes. The arraying accommodates subcarrier frequencies of 24 to 500 kHz and symbol rates from 2 ksps up to 250 kdps. The combining process introduces less than 0.2 dB degradation, and operates at received signal levels as low as

$$ST_s/N_o = -5.2 \text{ dB} \quad \text{34-m DSS}$$

$$ST_s/N_o = 0.8 \text{ dB} \quad \text{64-m DSS}$$

2. **Precision signal power measurement.** Capability is being provided at each DSS to measure precisely the received power in each carrier and the system noise temperature. This capability will be implemented in late 1979 at 64-meter DSSs, and in subsequent years for the other stations. The basic accuracy of these measurements will be 0.1 dB, with some degradation at strong and weak signals.

C. Planned Improvements

This article describes the current configuration and improvements being implemented. Future improvements are also planned in two areas:

(1) Enhancing the microwave performance to provide increased gain and lower noise temperature for the Voyager Saturn encounters.

(2) Addition of megabit (up to 30 Mbps) telemetry reception and detection for the Venus Orbiting Imaging Radar (VOIR) project.

Reference

1. Gatz, E. C., "DSN Telemetry System, Mark III-77," in *The Deep Space Network Progress Report, 42-42,* pp. 4-11, Jet Propulsion Laboratory, Pasadena, Calif., Dec. 15, 1977.

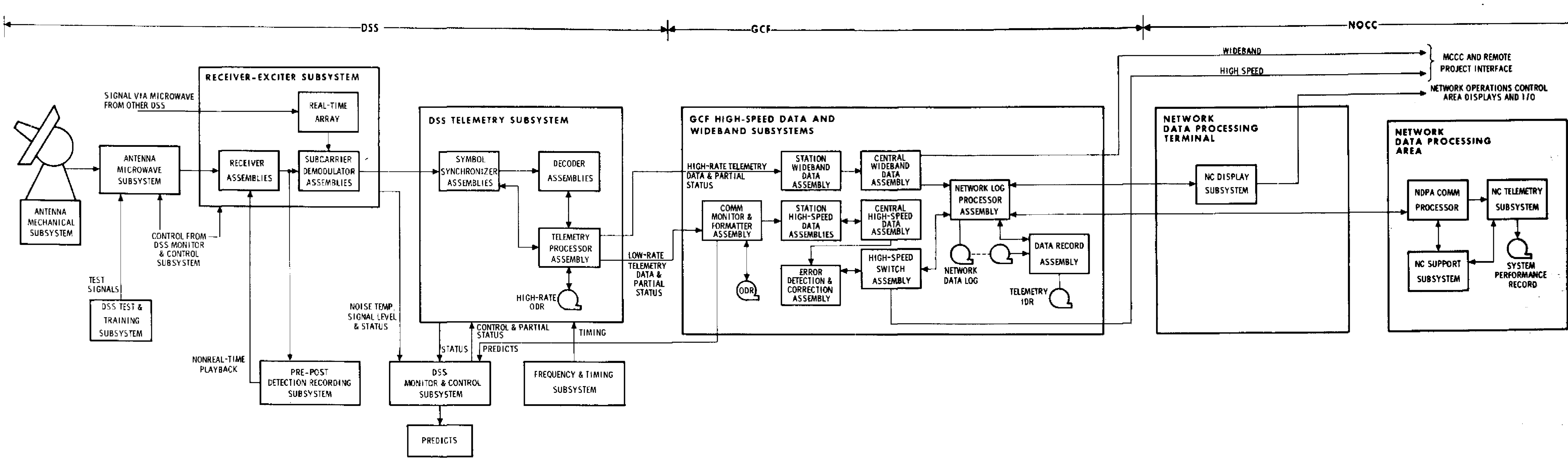

Fig. 1. DSN Telemetry System, Mark III-77, block diagram

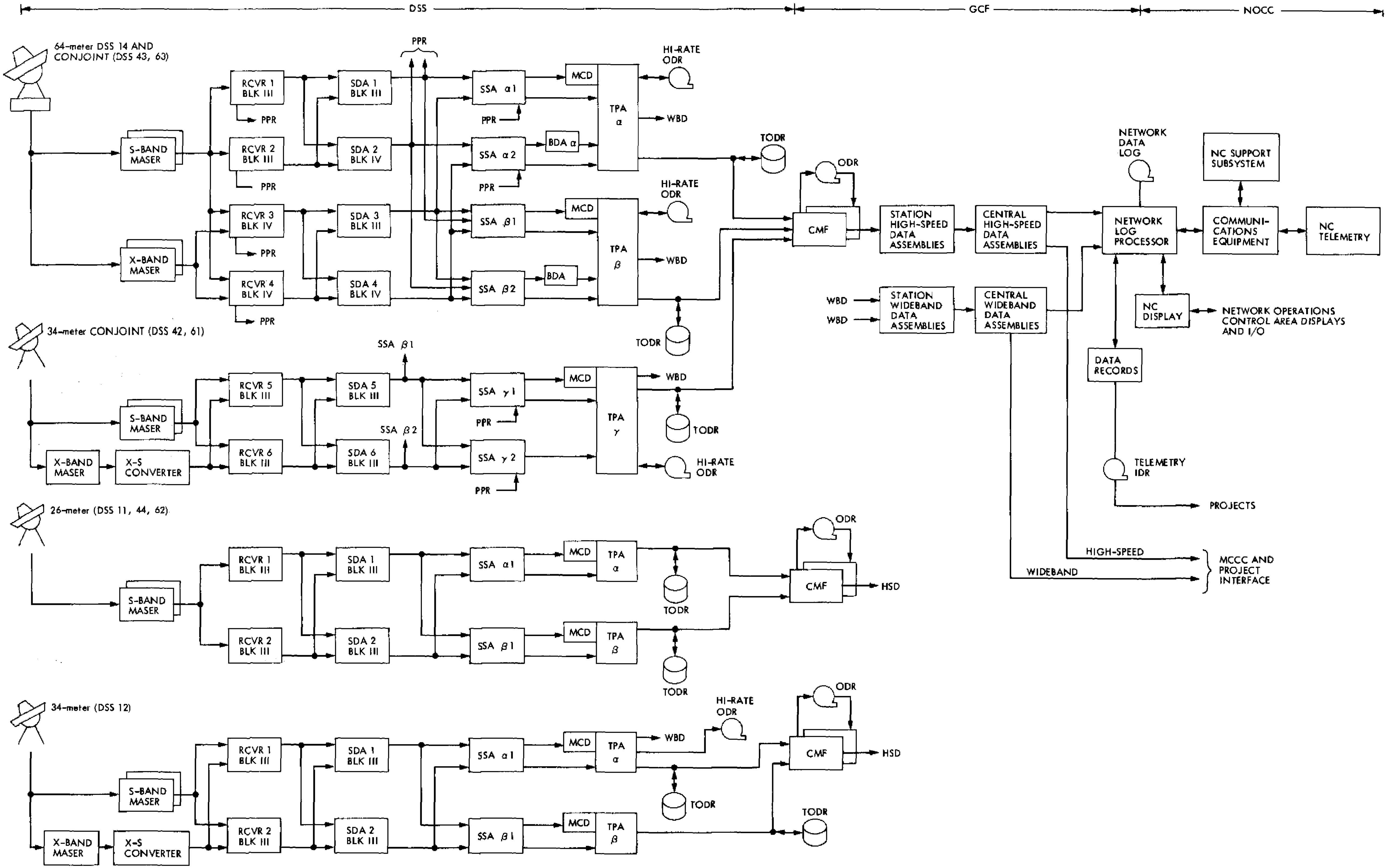

Fig. 2. DSN Telemetry System, Mark III-77 configuration